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(71) Applicant: TELEFONAKTIEBOLAGET LM ERICSSON
(publ) [SE/SE]; S-126 25 Stockholm (SE).(72) Inventor: EGNELL, Lars; Klubbvägen 14, S-133 37
Saltsjöbaden (SE).(74) Agents: LINDÉN, Stefan et al.; Bergenstråhle & Lindvall AB,
P.O. Box 17704, S-118 93 Stockholm (SE).

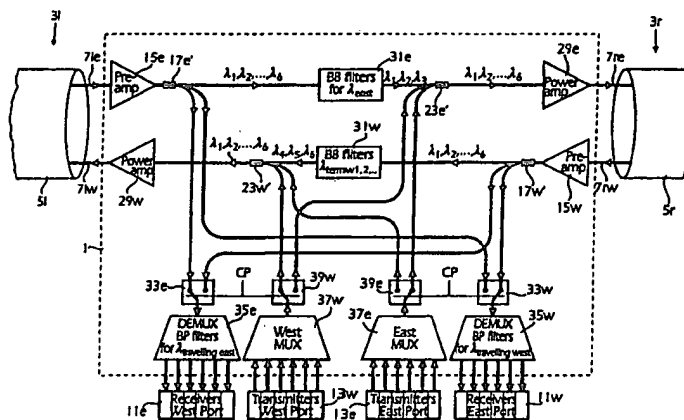
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(54) Title: AN ADD AND DROP NODE FOR AN OPTICAL WDM NETWORK HAVING TRAFFIC ONLY BETWEEN ADJACENT NODES



(57) Abstract

An optical fiber network of WDM type comprises two fibers (7e, 7w) which carry light signals propagating in opposite direction and which are arranged in a ring configuration. In the ring always one link between two neighbouring nodes is inactive but provides a standby-link which is used for failure in another link, in the case of which the previously inactive link is made active. An add and drop (1) node used in the network for only traffic between neighbouring nodes has band blocking filters (31e, 31w) connected in a fiber (7e, 7w) between a drop coupler (17e', 17w') and an add coupler (23e', 23w'). A drop coupler takes out equal shares of the light power to be received through switches (33e, 33w) and bandpass filters (35e, 35w) in receivers (11e, 11w). The add couplers add new wavelength channels produced in transmitters (13e, 13w) in the node through multiplexers (37e, 37w) and switches (39e, 39w). The switches (33e, 33w; 39e, 39w) are used for receiving and transmitting on the wavelength channels in correct directions depending on the location of the inactive link. Thus, the positions of two of the switches have to be changed when the inactive link is one of the two links directly connected to the node. Such a node has a minimum of in-line components and particularly a minimum of in-line filtering components.

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AN ADD AND DROP NODE FOR AN OPTICAL WDM NETWORK HAVING
TRAFFIC ONLY BETWEEN ADJACENT NODES

TECHNICAL FIELD

The invention relates to an add and drop node for an optical fiber network using
5 wavelength division multiplexing (WDM).

BACKGROUND OF THE INVENTION

Optical multi-channel systems employing wavelength multiplexing are used both in new
networks and in order to enhance the transmission capability of existing optical fiber
networks. Thus, information channels which previously had to be transmitted on a plurality of
10 separate fiber pairs are forwarded on a single fiber pair in WDM networks. Using optical
wavelength division multiplexed channels means that a plurality of serial information signals,
i.e. a plurality of serial binary signals, are transmitted on the same optical fiber by
modulating such a serial signal on a light signal, also called carrier, having a definite
wavelength and then combining the modulated light signals in an optical coupler or optical
15 multiplexer to a composite light signal on the considered optical fiber. The signal primarily
modulated on a monochromatic light signal or carrier together with the carrier can be called a
channel or traffic channel.

Self-healing optical fiber networks having a ring configuration are disclosed in U.S.
patent 5,442,623, but they are not particularly adapted to WDM-signalling. A similar network
20 designed for WDM-traffic is disclosed in the International patent application
PCT/SE98/00136. The networks described in these documents use an extra protecting fiber
pair between each pair of nodes.

Optical wavelength multiplexing can generally be used in different optical fiber network
configurations or architectures having e.g. only a single fiber pair between a pair of nodes.
25 Such an architecture is the FlexBusTM concept as described in B.S. Johansson et al.,
"Flexible bus: A self-restoring optical ADM ring architecture", Electronics Letters, 5th Dec.
1996, Vol. 32, No. 25, and U.S. patent application 08/421,734, this architecture comprising
a ring configuration of optical links connecting a plurality of nodes. The FlexBusTM concept
has emanated from the need for protecting ring networks against fiber cuts and optical
30 amplifier failures, and to solve the problem, often associated with ring network architectures,
of circulating signals and noise. In the FlexBusTM architecture one section of the fiber ring is
always made passive or inactive by means of optical switches or amplifiers. This intentionally
introduced break effectively eliminates all problems associated with circulating signals and
hence allows that less circuit components can be used and circuit elements having lower
35 performance can be used, while still retaining the shortest longest path possible. In the case
of a real failure of a link, that link which previously has been intentionally made inactive is
made active and the failed link now becomes the inactive link, what can be described by
having the inactive link moved from its former position to the failed section. This procedure
is called that "the bus flexes", and thereby the traffic is restored.

In the FlexBusTM channel blocking or selection filters placed in the lines are not needed, which alleviates the problems associated with concatenated filtering. The signal from one transmitter can be sent in both directions simultaneously without causing interference, and the same wavelength can be used in both directions, thus allowing the same number of bi-directional connections to be set up as the number of wavelengths that are used in the network.

With the maturing of filtering and switching technology it would, however, be beneficial to be able to reuse wavelengths more than once in order to be able to set up more connections and thus increase network capacity for the limited number of wavelengths that are feasible in a network with regard to available optical amplifier gain-bandwidth, realistic filter bandwidths and frequency stability of filters and light sources. Thus another implementation of a node architecture, based on the FlexBusTM but including a plurality of blocking filters and switches connected in-line, i.e. in the direct path of a fiber of the network or bus through the node, was invented and is disclosed in the published International patent application WO 96/31025 and is called the "Rearrangeable FlexBusTM". That implementation is capable of a very efficient use of the wavelengths. In the published International patent application WO 96/24998 an algorithm scheme for wavelength allocation in Rearrangeable FlexBusTM networks is disclosed.

The general architecture of the Rearrangeable FlexBusTM, see also the published International patent application WO 96/24998 and the International patent application "An optical WDM network having an efficient use of wavelengths and a node therefor", filed at the same time as the present application, is very efficient in using the available wavelengths and also very flexible as to the number of connections which can be set up in the network. Partly depending on the actual way in which networks often have been implemented, partly because of the requirement for truly adjacent traffic in networks, it appears to often exist an interest of finding good network solutions for adjacent traffic demands, i.e. for traffic between neighbouring stations or nodes. For a network having only such a kind of traffic, the channel by channel configurability is not necessarily required, and it is thus of interest to search for a simpler design of an add and drop node for this type of traffic pattern compared to that disclosed in the above-cited, simultaneously filed International patent application.

SUMMARY OF THE INVENTION

It is an object of the invention to provide an add and drop node for a network of the kind Rearrangeable FlexBusTM as described above and for traffic only between neighbouring nodes, the node having a minimum of in-line components and enhancing the reliability of the network but still having the good properties of the FlexBusTM and allowing an efficient use of wavelengths.

The problem to be solved by the invention is how to achieve, for a network of the kind Rearrangeable FlexBusTM having traffic between only neighbouring nodes, a node construction operating substantially as the nodes of that bus allowing an efficient wavelength

allocation in the network and allowing the network and the nodes to operate in a reliable way.

Thus generally, an add/drop node is designed to be connected in an optical fiber WDM network and for communication only with neighbouring nodes. The network has a ring configuration of two fibers carrying light signals in opposite directions and comprises links
5 connecting neighbouring nodes. For protection purposes, the network always has one link which is inactive and carries no light signals and the network has switching facilities allowing the inactive link to be made active and another link to be made the inactive link. The network carries light signals containing useful information in a plurality of separate wavelength bands. In the conventional way the node has drop couplers and add couplers for each direction for
10 taking out a share of light signals at the node and adding light signals in the node respectively and receivers for receiving light signals in wavelength bands in the node and transmitters for transmitting light signals in wavelength bands from the node into the network. A band blocking filter is connected between a drop coupler and an add coupler which are used for light signals in one direction for blocking in the same direction all wavelengths which are
15 received in the node from that direction. A switch is connected to a receiver and the drop couplers for allowing the receiver to receive from either one of the two opposite directions and/or a switch is connected to a transmitter and the add couplers for allowing the transmitter to transmit in either one of the opposite directions.

The receivers can be divided in two groups of west port receivers and east port
20 receivers. One switch is then preferably connected to all the receivers of one group for allowing all the receivers of this group simultaneously receive from either one of the opposite directions. Then an optical demultiplexer can be connected between the switch and the group of receivers.

The transmitters can also be divided in two groups of west port transmitters and east
25 port transmitters. One switch can then be connected to all the transmitters of one group for allowing all the transmitters of this group simultaneously transmit in either one of the opposite directions. An optical multiplexer is then advantageously connected between the switch and the group of transmitters.

BRIEF DESCRIPTION OF THE DRAWINGS

30 The invention will now be described by way of a non-limiting embodiment with reference to the accompanying drawings, in which

Fig. 1 is a general schematic view of an optical fiber network of WDM type using the flexible bus architecture,

Fig. 2 is a block diagram of a prior art add and drop node of a simple configuration for
35 the network of Fig. 1,

Fig. 3 is a block diagram of an add and drop node designed for communication between neighbouring nodes in the network of Fig. 2,

Fig. 4 is a picture showing an alternative design of a switching element used in the node of Fig. 3, and

Figs. 5a and 5b are graphs illustrating the assignment of wavelengths in a network of the kind illustrated in Fig. 1 having nodes according to Fig. 3 for two respective different locations of an inactive link.

DESCRIPTION OF A PREFERRED EMBODIMENT

5 A network using the basic flexible bus structure for WDM communication on optical fibers is illustrated in Fig. 1. A plurality of optical, add and drop nodes 1 are connected to each other by links 3 to form a network or bus comprising a physical ring structure having as basic elements a pair of optical fibers 7e, 7w connected to form two parallel fiber rings. Each fiber ring carries light propagating in a definite direction, the propagation directions of the
10 two rings being opposite to each other. Thus, in one of the fiber rings light always propagates in the counter-clockwise direction, in the embodiment of Fig. 1 the inner ring 7e, this direction being called the east direction hereinafter. In the other one 7w of the rings of the pair of fiber rings light always propagates in the opposite direction, i.e. in the clockwise direction, as seen in Fig. 1, this direction being called the west direction. A node 1 in the bus
15 structure is thus physically connected only to two neighbouring nodes, a left node and a right node. The connections of a considered node 1 thus include a left physical link 3l comprising a west line cable 5l and a right physical link 3r comprising an east line cable 5r, the other end of each link 3l, 3r being connected to the neighbouring left and right node respectively. Each piece 5l, 5r of line cables comprises a pair of optical fibers 7le, 7lw and 7re, 7rw
20 respectively, where in one 7le, 7re of the fibers of a fiber pair in a link 3l, 3r light always propagates in one direction, as in the east direction as seen in Fig. 1, and in the other one 7lw, 7rw of the fibers of the fiber pair in a link light always propagates in the opposite direction, in the clockwise or west direction, as seen in Fig. 1. Furthermore, a node 1 is connected to or contains receivers 11 and transmitters 13 for converting optical signals to
25 electrical signals and vice versa, the electrical signals being transferred or received respectively from other devices, links or networks, not shown.

One of the links 3 of the ring structure is always deactivated, see the link 2 in Fig. 1, so that at least no light carrying the useful information to be transferred in the network can pass therethrough, in neither direction. This prevents that such light signals and ASE noise
30 can circulate along the ring structure in several turns, ASE noise being amplified spontaneous emission produced in in-line optical amplifiers which are usually included in the nodes 1. When there is a failure in a link between neighbouring nodes, the network can be reconfigured so that this link will then be the deactivated one whereas the previously deactivated link (2) is now activated and operates like the other active links (3) in the ring structure
35 passing signals in the two opposite directions.

A basic structure of a node 1 in the basic flexible bus structure of Fig. 1 is shown in the block diagram of Fig. 2. The optical WDM traffic comprising a plurality of WDM channels having definite, separate wavelengths, each channel occupying a wavelength band around the wavelength of the channel, enters the node from the left or in the east direction

and from the right or in the west direction on the fibers 7le and 7rw respectively. The incoming signals can be amplified in optional optical preamplifiers 15e, 15w respectively in which the light signals are amplified. The incoming light is then split in drop couplers 17e, 17w. These couplers are optical power splitters that feed a portion of the total power of the light propagating in one direction in the bus, through an optical combining coupler 19, adding the deflected power portions from each direction to each other, to a bank 21 of filters, which can also be called an optical demultiplexer, having one or more bandpass filters for wavelengths used in the transmission in the network. Thus the filter bank 21 filters out channels, each channel carrying information in a definite wavelength band. The filtered-out light signals are then forwarded to opto-electrical receivers 11, one optical receiver being arranged for each received channel.

The remaining part of the light power split in the drop couplers 17e, 17w is forwarded through the node 1 and is in add couplers 23e, 23w mixed with new traffic to be added in the node. This new traffic is obtained from electro-optical transmitters 13, that each one transmits optical signals of a wavelength band or a channel different from that of the other transmitters. The output signals of the transmitters 13 are added to each other in an optical combining coupler or optical multiplexer 25, the resulting combined signal then being split in a splitting coupler 27 in two portions having equal power, one of the two portions being transmitted to one of the add couplers 23e, 23w and the other portion being transmitted the other one of the add couplers. The light signals obtained from the add couplers 23e, 23w for each direction are fed to the fibers 7re, 7lw, which are contained in the links 3r, 3l connected to the node and carrying light going out from the node, through optional optical power amplifiers 29e, 29w.

In the node design as illustrated in Fig. 2 the lack of in-line blocking filters and in-line switches should be observed and in particular that light propagates through or passes the node in a substantially unaffected or uninterrupted way. Furthermore, the transmitters 13 are sending in and the receivers 11 are listening to both traffic directions simultaneously. The left side or the right side amplifiers 15e, 29w or 15w, 29e respectively can be used to deactivate the respective links or segments 3l, 3r connecting the node to the two neighbouring nodes. This is made in the case where this link is to be the deactivated one, such as in the case of a failure of this link. Such a failure can be caused e.g. by one of the fibers of the pair of the link being broken or by one of the optical amplifiers connected to this link being faulty.

The bus structure and node design according to Figs. 1 and 2 are described in the above cited article by B.S. Johansson et al. and in the cited U.S. patent application 08/421,734. However, this structure only allows that a considered wavelength or channel is used once in the network in each direction, such as for communicating between two nodes. A node architecture allowing a reuse of wavelengths, i.e. that a channel or wavelength is used more than once for transferring information in one direction, is disclosed in the cited International patent application WO 96/31025 resulting in a more efficient use of available wavelengths.

However, this prior node design has a multitude of demultiplexers and switches connected in-line, i.e. in the direct path of a fiber of the network or bus through the node. Still, this prior node allows a very efficient use of the wavelength range or equivalently a very efficient use of available channels.

5 For the strictly adjacent traffic situation, all wavelengths can be reused between all node pairs, see the schematic picture of Fig. 5a. In this ring network traffic only occurs between neighbouring nodes, the term neighbouring being taken generally with respect to the ring configuration. Thus, all pairs of neighbouring nodes having an active link or the inactive link between them communicate with each other. Here a network having six nodes is shown,
 10 using six different wavelength channels having wavelengths $\lambda_1, \lambda_2, \dots, \lambda_6$. The wavelengths $\lambda_4, \lambda_5, \lambda_6$ are for each node except the east-most one used for transmitting on the fiber 7re for east going traffic to the most adjacent node on the east side of the node, these same wavelengths being used by the east-most node for transmitting to the west-most node using the fiber 7lw for west going light signals. In the similar way, the wavelengths $\lambda_1, \lambda_2, \lambda_3$ are
 15 for each node except the west-most one used for transmitting on the fiber 7lw for west going traffic to the most adjacent node on the west side of the node, these same wavelengths being used by the west-most node for transmitting to the east-most node using the fiber 7re for east going light signals. In Fig. 5b the same network is illustrated after a relocation of the inactive link 2, in which the wavelength allocation is also visible and from which it can be deduced
 20 how the transmission and reception of wavelength channels must be changed.

It is then obtained, as can easily be seen from Fig. 5a, that for N_λ wavelengths, where N_λ is assumed to be an even number, $N_\lambda/2$ connections between each adjacent node pair can be set up, which implies $N \times N_\lambda/2$ connections for a network having N nodes.

In order to be able to do this, one has to block all east going and all west going reused
 25 wavelengths in each node. This can be done by arranging simple in-line blocking filters. Then there is a possibility to arrange the wavelength allocation such that these blocking filters can have a simple construction, see the block diagram of an add and drop node suited for traffic between only adjacent nodes in Fig. 3. In Figs. 3 and 2 the same reference signs are used for identical or corresponding elements. One possibility of designing such blocking filters may be
 30 to arrange e.g. the lower half of the total wavelength window for the east going channels and the upper half of the window for the west going channels with a guard space between the bands, i.e. in the example that all the wavelengths $\lambda_1, \lambda_2, \lambda_3$ are smaller (or greater) than all of the wavelengths $\lambda_4, \lambda_5, \lambda_6$. Then e.g. single bandblocking filters or even lowpass and highpass filters can be used as bandblocking filters for each direction.

35 A node can then be divided into a west port and an east port, each port having suitable switches not connected in-line for allowing a change of direction of some of the wavelength channels when the node is changed from being an inner node to an east-most or west-most mode, directly connected to the inactive link. The receivers are then divided in east port receivers 11w for receiving from the eastern direction, i.e. from the adjacent node located at

the east side of the node, and west port receivers 11e for receiving from the western direction, i.e. from the adjacent node located at the west side of the node, the directions being indicated for the node being assumed not to be the west-most or east-most node, i.e. not a node directly connected to the inactive link 2. For the west-most node the west port
 5 receivers 11e are instead used for receiving from the east-most node and for the east-most node the east port receivers 11w are used for receiving from the west-most node by changing the setting of switches, as will be described hereinafter, see also Figs. 5a and 5b. In the same way, the transmitters are divided in east port transmitters 13e for transmitting in the eastern direction, to the adjacent node located at the east side of the considered node, and west port
 10 transmitters 13w for transmitting in the western direction, to the adjacent node located at the east side of the node, the directions being also indicated for the case where the considered node is connected to be an inner node, not directly connected to the inactive link 2. For the west-most node the west port transmitters 13w are also used for transmitting to the east-most node and for the east-most node the east port transmitters 13e are also used for transmitting
 15 to the west-most node.

Since it is not necessary to be able to switch on a channel by channel basis in the node of Fig. 3, it is sufficient to arrange one switch element for each group of receivers 11e, 11w and each group of transmitters 13e, 13w, instead of one switch for each received channel and each transmitted channel in the node, as proposed in the already cited, simultaneously filed
 20 International patent application "An optical WDM network having an efficient use of wavelengths and a node therefor".

Thus, in both directions in the middle of the node illustrated in Fig. 3, simple blocking filters 31e, 31w are inserted between that output of the drop coupler 17e', 17w' carrying the signal to be forwarded through the node and an input of the respective add coupler 23e',
 25 23w'. The drop couplers 17e', 17w' are similar to the drop couplers 17e, 17w of Fig. 2 but tap off, from the light power passing in each direction, two substantially equal shares of power, each drop coupler 17e', 17w' thus having three output terminals or lines. The light signal incoming to the node in each direction includes all wavelengths $\lambda_1, \lambda_2, \dots, \lambda_6$ used in the system, according to the example of Figs. 5a and 5b. For an inner node half the number
 30 of wavelengths are terminated in the node for each direction, so that for the example of Figs. 5a and 5b the wavelengths $\lambda_4, \lambda_5, \lambda_6$ in the east-going direction are terminated and the wavelengths $\lambda_1, \lambda_2, \lambda_3$ in the west-going direction are terminated in an inner node. A wavelength channel is said to be terminated in a node if it is received in the node, i.e. if there is a receiver 11e, 11w for this channel in the node.

35 Each of the blocking filters 31e, 31w in the considered node blocks only those wavelengths $\lambda_4, \lambda_5, \lambda_6$ and $\lambda_1, \lambda_2, \lambda_3$ respectively which are terminated in the node for the respective direction, where it is supposed that the node is connected as an inner node or not as an end node connected to the inactive link. All wavelengths not included in the set $[\lambda_4, \lambda_5, \lambda_6]$ are then just passed through the node in the east going direction in a basically unaffected

or uninterrupted way and in the same way all wavelengths not included in the set $[\lambda_1, \lambda_2, \lambda_3]$ are just passed through the node in the west going direction in a basically uninterrupted way, where it is again supposed that the node is connected as an inner node.

Like the node according to Fig. 2 the optional preamplifiers 15e, 15w each have their
 5 outputs connected to a respective drop coupler 17e', 17w'. The drop couplers couple the two, preferably equal, deflected shares of the power of the received light to 2:1 switching elements 33e, 33w, so that each such switching element receives on its two inputs a share of the light power propagating in the two opposite directions. Such a 2:1 switching element 33e, 33w has its single output terminal connected to the input of a respective demultiplexer 35e, 35w and
 10 each of its input terminals is thus connected to a separate one of the drop couplers 17e', 17w'. The demultiplexers or filter blocks 35e, 35w correspond to the filter block 21 of Fig. 2 and perform the necessary demultiplexing or bandpass filtering for the wavelength channels to be received in the receivers 11e, 11w, the light receivers or light detectors used in the conventional way for detecting only the power of the received light. Thus one filter block 35e
 15 contains bandpass filters for each of the wavelengths $\lambda_4, \lambda_5, \lambda_6$, which correspond to channels in the east going direction and are terminated in the node, and another filter block 35w contains bandpass filters for each of the wavelengths $\lambda_1, \lambda_2, \lambda_3$, which correspond to channels in the west going direction and are terminated in the node, the directions being indicated for the case where the node is an inner node. The output of each of the filters in
 20 such filter block 35e, 35w, which thus carries a light signal of a specific wavelength or of a specific narrow wavelength interval, is connected to a respective receiver 11e, 11w.

Each transmitter 13e, 13w has its output terminal directly connected to one of two multiplexer blocks 37e, 37w, these multiplexers corresponding to the multiplexer 25 of Fig. 2, one multiplexer block 37e being arranged for traffic in the east direction and one
 25 multiplexer block 37w for traffic in the west direction, the directions being again indicated for the case where the node is connected to be an inner node. A 1:2 switching element 39e, 39w has its single input terminal directly connected to the output of a respective multiplexer 37e, 37w and each of its output terminals is connected to one of the add couplers 23e', 23w' for adding the transmitted combination of wavelength channels in the respective direction,
 30 depending on the position of the switching element. The add couplers 23e', 23w' which correspond to the add coupler 23e, 23w of Fig. 2 thus here add two signals to the traffic passing through the node and has three inputs.

If in the node of Fig. 3 a wavelength channel is received from one direction and then also blocked in the node in this direction, the same wavelength channel must be able to
 35 propagate through the node on the other fiber in the opposite direction without being blocked in the node, see Figs. 5a and 5b. In Fig. 3 the positions of the switching elements 33e, 33w and 39e, 39w are illustrated for a node not connected as an end node, i.e. in the case in which it is not connected at one of its sides to the inactive link. If the bus has to flex owing to some failure and the node then becomes connected directly to the inactive link, one of the

receiver switching elements 33e, 33w then has to change its position and that one of the switching elements 39e, 39w connected through a multiplexer 37e, 37w to transmitters 13e, 13w which is located in the same side or port of the node also has to change its position, i.e. when a receiver switching element receiving from traffic going in a first direction has to change also that transmitter switching element has to change which transmits in a direction opposite to the first direction. The receiver and transmitter switching elements 33e, 39w and 33w, 39e for changing the paths for a correct connection with another node, i.e. for receiving from and transmitting correctly to the other node, can thus be linked to the same triggering point, indicated as "CP" in Fig. 3, simplifying the procedure which must be executed by some control unit, not shown, arranged to control the position of the switching elements to allow the bus to "flex". It can be observed that the wavelengths blocked by the blocking filters 31e, 31w in each direction do not have to be changed for a flexing situation.

Thus in particular, the west port switching elements 33e, 39w for the west port demultiplexer 35e and the west port multiplexer 37w are to be in the west position, as shown in Fig. 3, unless the considered node is the west-most node of the bus, whereas the east port switching elements 33w, 39e should be in the east position illustrated in Fig. 3, unless the considered node is the east-most node of the bus.

For reliability reasons it may be advantageous to replace all switching elements by a unit 41 combined of a 1:2 coupler 43 and a simple on/off-switch 45, as illustrated in Fig. 4. The on/off-switch 45 is arranged in the branch which is most likely to be open, these positions appearing from Fig. 3, and is open in all nodes except in the west-most and east-most nodes where it is closed in two switching elements. The link which is to be deactivated can be made inactive by always letting the west port amplifiers 15e, 29w in the new west-most node block all signals coming from and going to the west and in that node also the on/off-switches in the west port are then closed. In the corresponding way, in the new east-most node always the east port amplifiers 15w, 29e can be made to block all signals coming from and going to the east and in that node also the on/off-switches included in the switching elements in the east port are closed.

CLAIMS

1. An add/drop node arranged to be connected in an optical fiber WDM network and for communication only with neighbouring nodes, the network having a ring configuration of two fibers carrying light signals in opposite directions, the network comprising links
5 connecting neighbouring nodes, the network always having one inactive link carrying no light signals and being arranged to allow that the inactive link is made active and another link is made inactive, the network carrying information in a plurality of separate wavelength bands, the node comprising drop couplers and add couplers for each direction for taking out a share of signals at the node and adding signals in the node respectively and receivers and
10 transmitters for receiving light signals in wavelength bands in the node and transmitters for transmitting light signals in wavelength bands from the node into the network, characterized by

a band blocking filter arranged between a drop coupler and an add coupler for blocking in one direction all wavelengths which are received in the node from that direction,

15 a switch connected to a receiver and the drop couplers for allowing the receiver to receive from either one of the two opposite directions and/or

a switch connected to a transmitter and the add couplers for allowing the transmitter to transmit in either one of the two opposite directions.

2. An add/drop node according to claim 1, characterized in that the receivers are
20 divided in two groups of west port receivers and east port receivers, one switch being connected to all the receivers of one group for allowing all the receivers of this group simultaneously receive from either one of the two opposite directions.

3. An add/drop node according to claim 2, characterized by an optical demultiplexer connected between a switch and a group of receivers.

25 4. An add/drop node according to any of claims 1 - 3, characterized in that the transmitters are divided in two groups of west port transmitters and east port transmitters, one switch being connected to all the transmitters of one group for allowing all the transmitters of this group simultaneously transmit in either one of the two opposite directions.

5. An add/drop node according to claim 4, characterized by an optical multiplexer
30 connected between a switch and a group of transmitters.

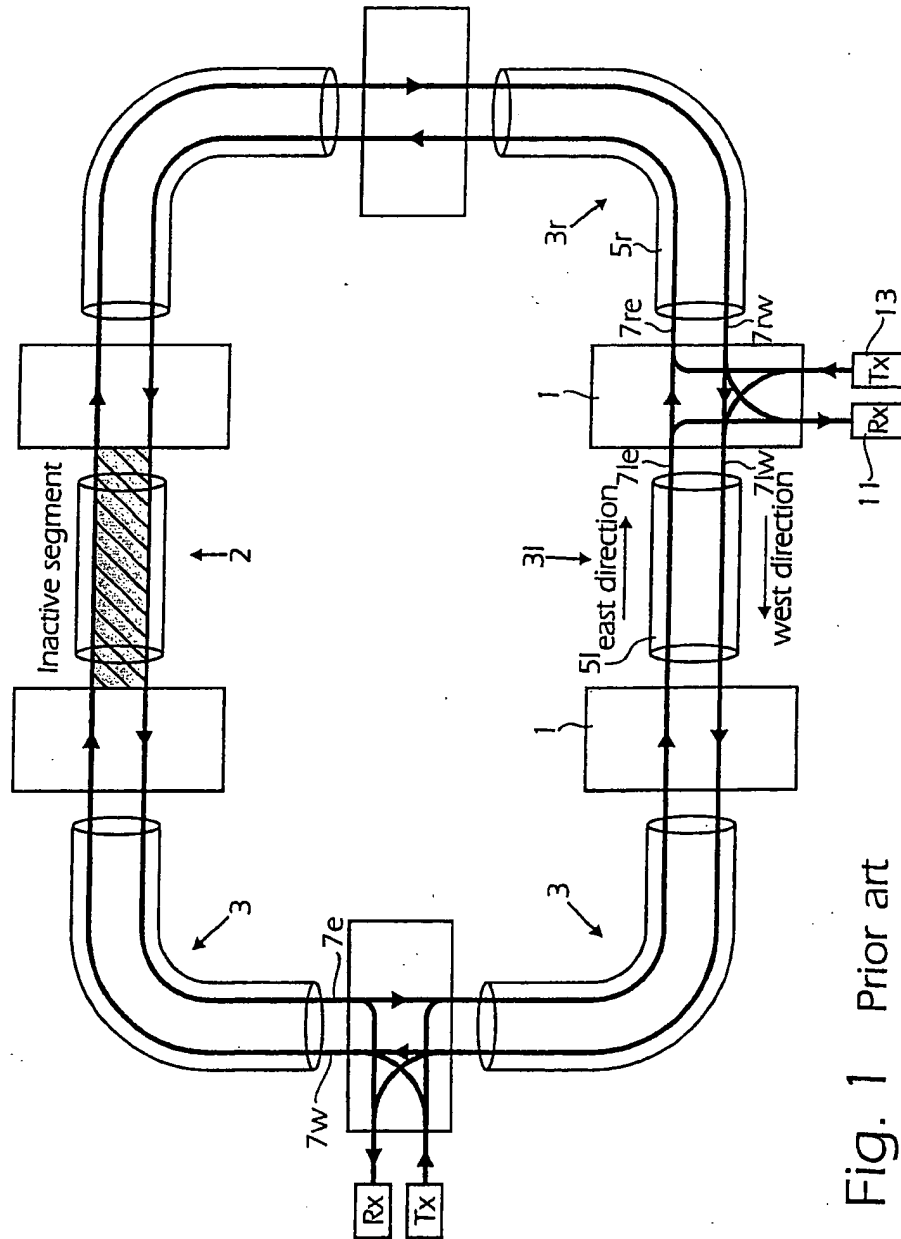
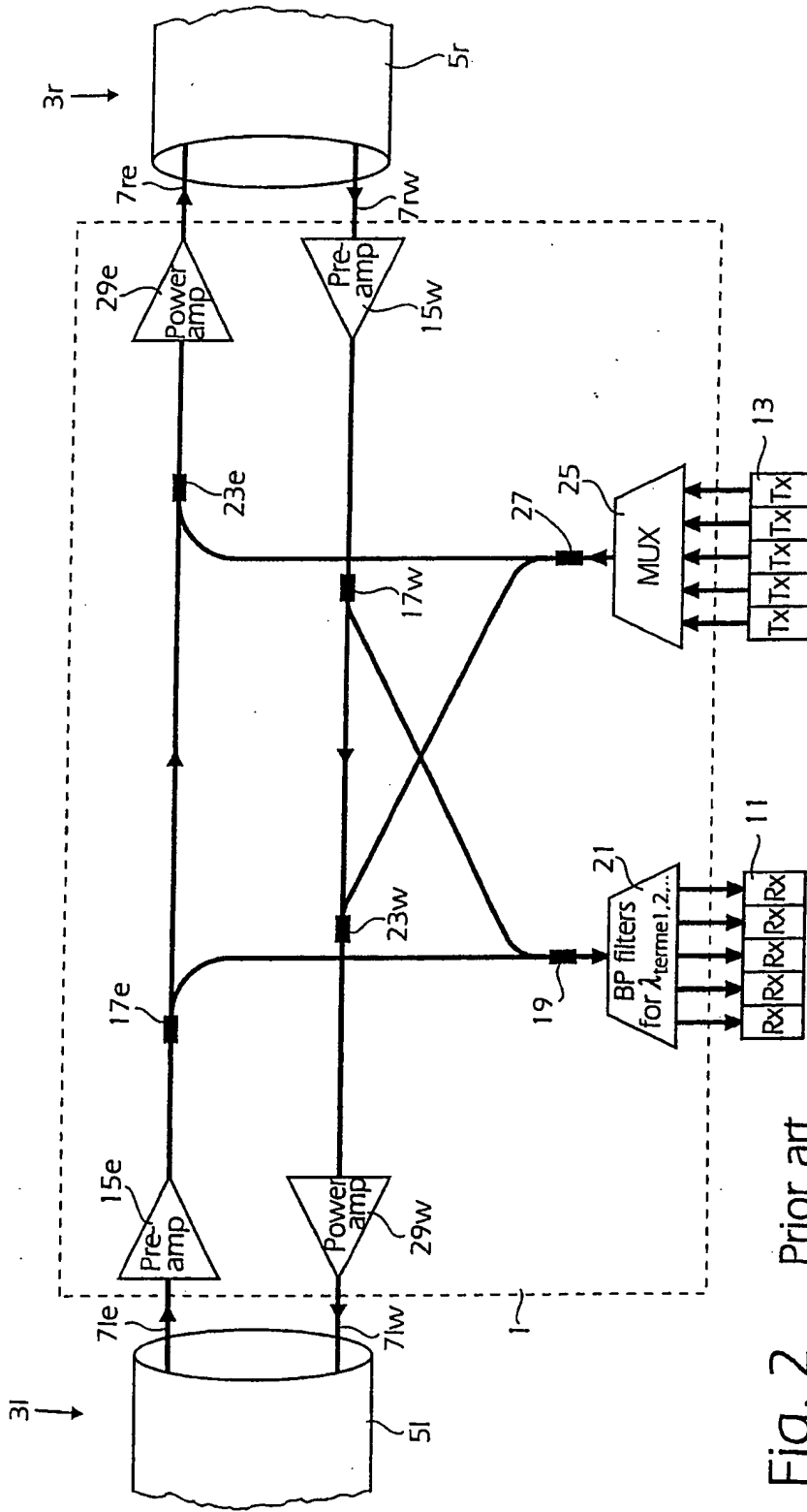


Fig. 1 Prior art



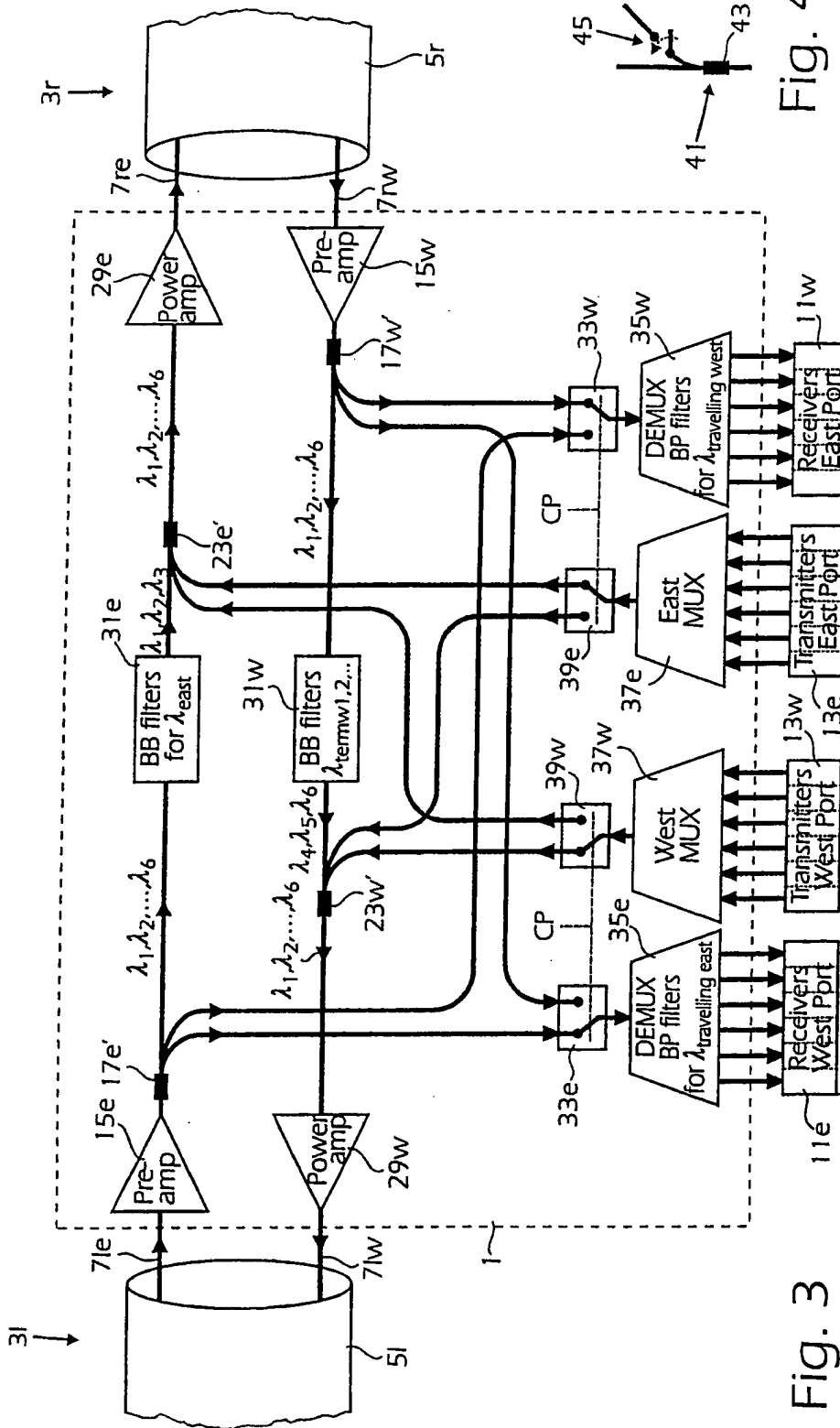


Fig. 4

Fig. 3

Fig. 5a

z

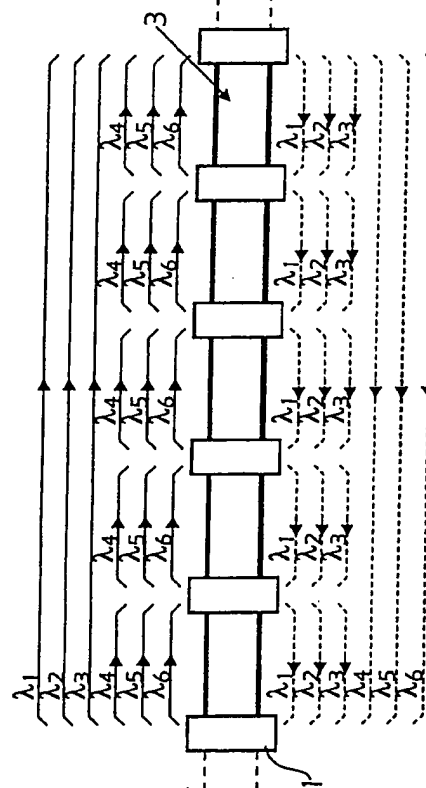
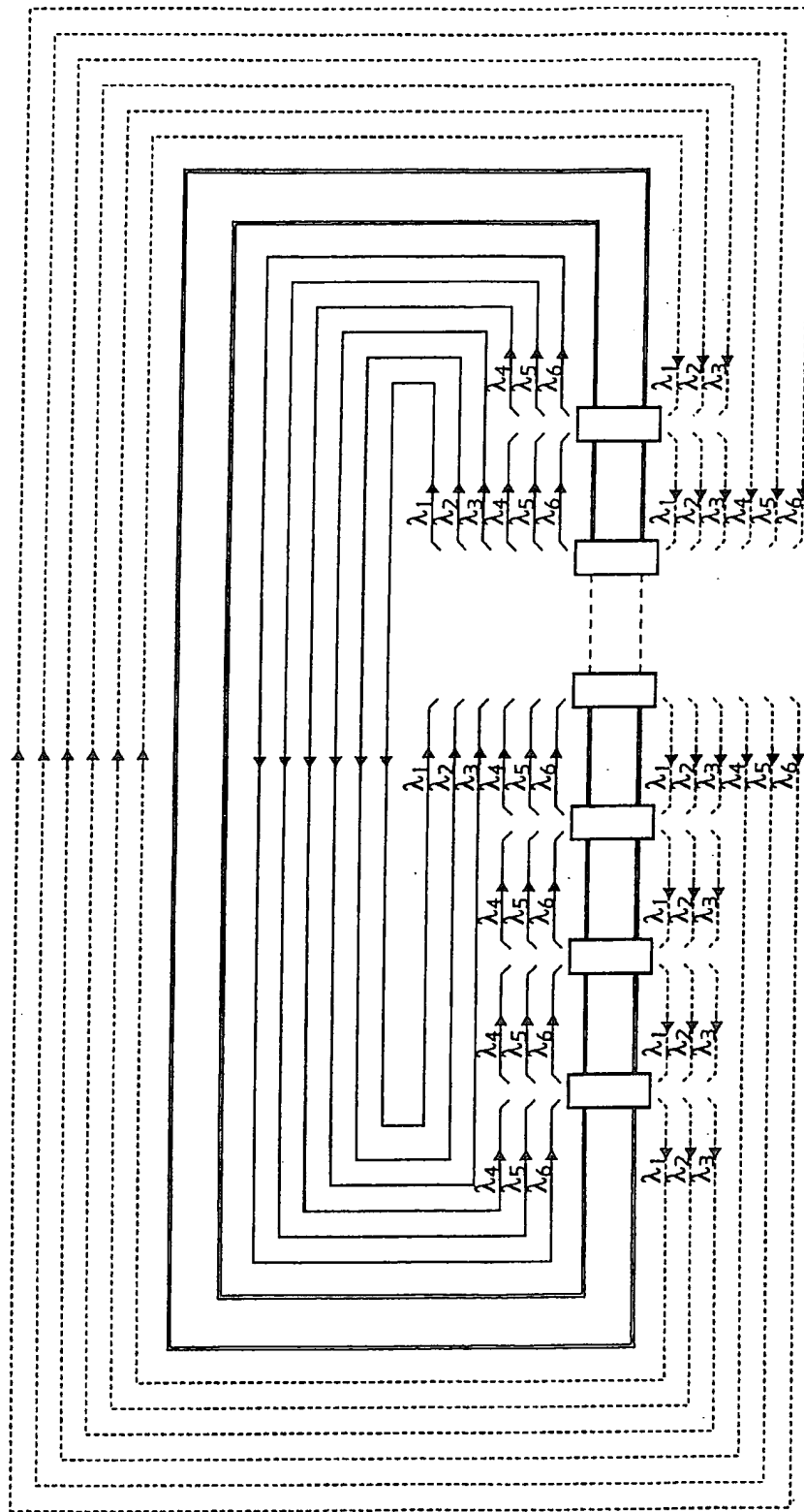


Fig. 5b



INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 99/00994

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04B 10/213, H04J 14/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04B, H04J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, WPIL, JAPIO, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0769859 A1 (PIRELLI CAVI S.P.A.), 23 April 1997 (23.04.97), column 1, line 1 - column 3, line 45, claims 1-6, abstract --	1-5
P,A	WO 9849794 A2 (TELEFONAKTIEBOLAGET LM ERICSSON), 5 November 1998 (05.11.98), see whole document --	1-5
A	US 5442623 A (TSONG-HO WU), 15 August 1995 (15.08.95), column 6, line 15 - line 43, claims 1-5, abstract, cited in the application --	1-5

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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Date of the actual completion of the international search

21 October 1999

Date of mailing of the international search report

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Name and mailing address of the ISA/

Swedish Patent Office

Box 5055, S-102 42 STOCKHOLM

Facsimile No. +46 8 666 02 86

Authorized officer

RogerBou Faisal/MN

Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 99/00994

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9631025 A1 (TELEFONAKTIEBOLAGET LM ERICSSON), 3 October 1996 (03.10.96), page 1, line 5 - page 3, line 6, claims 1-5, abstract, cited in the application --	1-5
A	WO 9701907 A1 (TELEFONAKTIEBOLAGET LM ERICSSON), 16 January 1997 (16.01.97), page 1, line 5 - page 3, line 5, claims 1-5 -- -----	1-5

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Information on patent family members

28/09/99

International application No.
PCT/SE 99/00994

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